A Universal Graphic Character Writer

by

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ABSTRACT

A major barrier to the human communication is attributed to the fact that there is no compatible typewriter, as in the Western World, for any non-alphabetic language outside of the Western World. This paper will describe how a plotter can be used through programming, as a universal graphic character writer for all non-alphabetic as well as alphabetic languages in place of the typewriter. This is economically feasible since the plotter is not expensive and can be driven by a small computer on-line, or off-line using a plotter and tape unit.

Each character is treated as a single independent graph and decomposed into line segments within a 16 x 16 grid for non-alphabetic languages, and a 5 x 8 grid for alphabetic languages. Therefore, the graphic character can be represented by the coordinates which indicate the beginning and the ending points of the line segments.

To take the most complicated Chinese language as an example, the character for "BRAVE" (勇) can be represented by twenty-three pairs of coordinates and packed into four 48-bit computer words. Taking this as a basis for estimation, the overwhelmingly numerous 10,000 Chinese characters can be decomposed and packed into 40K

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of memory. Thus, a computer with 65K memory will be able to keep them in core for direct access and processing.

On the other hand, an English letter "M" can be represented by five pairs of coordinates and packed into one 48-bit computer word. In other words, the whole set of the English alphabet, including upper and lower cases, will need only 110 words of memory.

The output on the plotter is itself a good hard copy to keep, and certainly it can be used as an original for further duplicating, photographing and photoengraving.

I. INTRODUCTION

This paper describes a system which simulates the function of a typewriter for all languages because of its unique nature in the coding and displaying of the graphic characters. Characters, including alphabets, of all languages are encoded on a grid. However, for the internal representation in the memory, only the X-Y coordinates of each straight line segment are recorded, which will provide sufficient information to reconstruct this character. The test program for this system is written in CDC 3600 FORTRAN (a variation of FORTRAN IV) which will generate a plot tape to be used on a Calcomp plotter for producing these characters. Actually, with some minor modifications, this program can be run on any computer and output on any plotter available. The advantage in using the plotter is that it produces directly a clear, hard copy at a very reasonable cost. Natural languages which have been tested in the program are Chinese and English. French, German, Hindi, Hebrew, Italian, Japanese, Korean, Russian, and Spanish are to be tested in the near future.

II. CHARACTER REPRESENTATION

Different sizes of grids may be used to define the coordinates representing each character. For non-alphabetic languages, a 16 x 16 grid is proved to be sufficient for a good recoding of the character. For alphabetic languages, a 5 x 8 grid will be adequate to accommodate all the letters of the languages. Each grid point in the grid is assigned a pair of values according to its relative position in the grid, that is, the coordinates of the grid point. The rows of the grid points are numbered from the bottom up, from 0 to 15 or 7 as the Y coordinate. The columns of the grid points are numbered from the left to right, from 0 to 15 or 4 as the X coordinate. The character is to be fitted into the grid with one restriction that all the starting points, turning points, and ending points of a line or line segment have to be on one of the grid points. The coordinates of these grid points are recorded and to be stored in the memory for later retrieval. A curve of a stroke is treated as many short straight line segments. A line is defined here with only one starting point and one ending point, and may or may not have one or more turning points between them. Coordinates of a line should always be recorded in the sequence as the starting point, the turning point or points, and the ending point. However, the sequence of coordinate groups of lines are immaterial for the character representation.

The character representation method used by Hayashi, Duncan and Kuno of Harvard University is not quite the same as described above. Instead of recording the starting point, turning point and ending point of a continuous line, they virtually recorded the starting point and ending point of every line segment. That is, the turning point in a continuous line is used twice both as the ending point of the previous line segment and the starting point of the following line segment. This method does simplify the programming task for generating the character, but it also increases the number of coordinates to be recorded and stored for retrieval, resulting in inefficient character generation. Taking their example of a Chinese character for "BRAVE" (勇), thirty-two pairs of coordinates are required to be stored for character generation. For the method described in the previous paragraph, only twenty-three coordinate pairs are necessary to accomplish the same task. If the English letter "M" is taken as an example, eight coordinate pairs are required for the Harvard method, of which, only five coordinate pairs are necessary to reconstruct the character excluding the three repeated coordinate pairs.

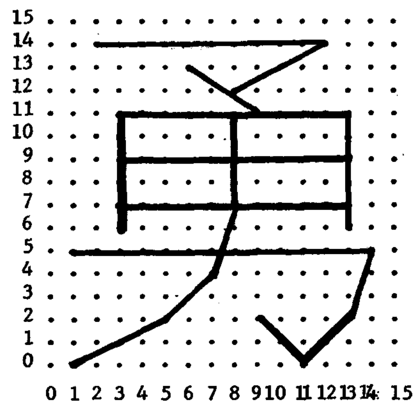

Figure 1. The Chinese character for "BRAVE" on a 16 x 16 grid with twenty-three pairs of coordinates:

(2,14), (12,14), (8,12);
(6,13), (9,11);
(3, 6), (3,11); (13,11), (13, 6);
(3, 9), (13, 9);
(3, 7), (13, 7);
(8,11), (8, 7), (7, 4), (5, 2), (1, 0);
(1, 5), (14, 5), (13, 2), (11, 0), (9, 2).

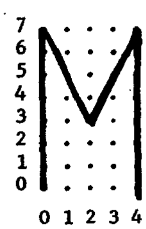

Figure 2. The English letter "M" on a 5 x 8 grid with five pairs of coordinates:

(0, 0), (0, 7), (2, 3), (4, 7), (4, 0).

There are other methods to represent a character. One method uses a 256 x 256 or some other size cell grid. Each cell is one bit in size to record the presence of the character strokes, lines or dots as the one bit, and the non-presence of them as the zero bit. Then, by resembling these bits into a pattern, it is used for the recognition or generation of a character. This method is employed for almost all commercial character recognition machines to identify English letters, symbols and numerals most often in printed form. However, this is not practical for the non-alphabetic languages because it requires a huge memory to store all these character cell-patterns. For example, one commercial machine actually uses a 2,048 x 2,048 cell grid to recognize an English letter with good precision. In addition, this method is not used for character generation because of the foreseeable programming complications and the time-consuming computer operations.

Another method is to choose some special codes for identifying the characters. An arbitrary code system can be used for this purpose, such as the telegraphic code of Chinese characters. They are four decimal-digit codes ranging from 0000 to 9999 for representing the 10,000 Chinese characters in use. They are rather arbitrarily assigned except that characters with certain stroke patterns are grouped together and the sequence arranged is closely associated with the sequence appearing in most Chinese dictionaries. Another good example is the Binary Coded Decimal used in computers to specify the individual English letters, numerals and symbols.

An alternative is to assign a code according to certain pattern or the arrangements of the strokes such as the method used by the IBM Sinowriter which was revised later by Itek Corporation and renamed as the Chicoder. It also uses four digit codes but the first two digits are alphanumerics and the last two digits are numerals ranging only from one to five. The advantage of this method is that it eases the memory retention of codes by the operator.

These two code assignment methods can also be applied to other languages as well. However, if characters are to be generated directly from those identifying codes then the coding of those characters is actually in some sort machine language for system macros and it could be very tedious and complicated. Therefore, these two methods are not recommended for generating characters but only for identifying characters during retrieval phase.

II. CHARACTER GENERATION

The codes for identifying different characters in various languages are just different forms of identification such as the illustrations of letters, numerals and special symbols on the keys of every typewriter keyboard. Once the code is recognized either through the input media or through some internal transformation, the coordinate group associated with this particular code will be retrieved for character generation.

Character generation through programming is basically a procedure of initiating proper subroutine calls to plot a straight line between two pairs of coordinates at a specified position. The difference between character generation through CRT beam displaying and through plotter pen drawing is a matter of different subroutine calls for activating different hardware output devices.

The character generation method employed in the test program is elaborated to the extent that once the plotter pen is lowered for drawing, it is maintained at that position until the drawing of the current continuous line is completed and then it is lifted and set ready for the movement of the pen to the starting point of the next continuous line. In the case of a CRT display, once the beam is turned on for displaying a line, it will not be turned off until the end of this continuous line is reached. Thus, the coordinate group of a continuous line is treated as a unit for the generating purpose. The first pair of coordinates in a coordinate group, i.e., the coordinate pair of the starting point of a line, initiates the pen or beam to be moved to the position specified by this pair of coordinates, and then to be lowered or turned on at that position. The second pair and all the succeding pairs of coordinates up to the second to the last pair, i.e., the coordinate pairs of the turning points, will each activate one movement of the pen or beam to the specified coordinate position forming a straight line segment of the continuous line. The last pair of coordinates, i.e., the coordinate pair of the ending point, will move the pen or beam to the specified coordinate position and then lift the pen or turn off the beam at that position.

The Harvard method is simpler and easier in programming in the sense that a generating unit contains only two pairs of coordinates: the first pair as the starting point of a straight line, and the next, or the last, pair as the ending point, which work the same way as indicated in the test program. However, since there is no turning points involved, a non-straight line must be broken into many short straight lines with repeated coordinates to indicate both the ending of the previous line segment and the starting of the following line segment. Thus a non-straight line with N straight line segments will have to be drawn or displayed N times with the plotter pen moved, lowered, moved again, and lifted every time, or with the CRT beam moved, turned on, moved again, and turned off every time.

IV. FORMAT CONTROLS

In order to have the characters to form a meaningful text and to be arranged in different forms, certain format controls are not only desired but also of necessity:

1. Language Selection

The user is allowed to choose from all available languages in the system one or more desired languages to be written on the plotter paper. The first language selected also indicates the mode of input codes. Thus if more than one language selection is specified, the other languages selected will be written in parallel, in an equivalent word-for-word translation of the first language selected. A multiple-language machine dictionary is utilized for this purpose.

2. Vertical or Horizontal Writing

The writing direction of characters may be either vertical or horizontal. Non-alphabetic languages are usually written vertically from top downward for characters and from right to left for columns. Alphabetic languages are always written from left to right for characters and from top downward for rows. It is recommended that for multiple-language writing including both alphabetic and non-alphabetic languages, the horizontal writing mode is more suitable since non-alphabetic languages will still be readable vertically while in the other case to read alphabetic languages in vertical fashion will be much more difficult in a continuous text.

3. Character Size and Inter-character Spacing

The number of characters to be accommodated on a standard size 8-1/2 x 11 inch page is determined by the character size specified which will also in turn allot the spacing between characters row-wise and column-wise. The character size is specified in terms of step size, that is,the smallest distance between two specifiable pen positions, or the number of points to be positioned within the distance of one inch. The step size is to be treated as the unit distance between two grid points in the 16 x 16 and the 5 x 8 grids. Step sizes considered appropriate for character writing for various visual effects are: 0.01, 0.015, 0.02, 0.025, and 0.04 inches. For examples, step size of 0.025 will yield 320 Chinese characters written horizontally, 0.02 inches for 500 characters, and 0.01 for 2,000 characters.

4. Blank Character

This is used for all kinds of spacing needs in terms of one character size of blank spaces. Some typical uses are those of centered titles with blank characters filled on both left and right or top and bottom, indention at the beginning of rows or columns, blank filled endings of rows or columns, blank spaces between words and sentences in alphabetic languages, etc.

5. Line and Page Controls

In contrast to the above user-specified controls, the line and page controls are automatic system controls which can only be influenced through the character size selection and the language selection. The program will calculate the total number of characters to be written on a 8-1/2 x 11 inch page according to the selected character size and language (alphabetic or non-alphabetic). Then the number of characters per line (row or column) will be calculated accordingly. When the end of a line is reached, the next character will be written on the first character position of the next line. And, if the end of a page is reached at the same time, the plotter paper will be advanced to the next standard size page with the next character to be written on the first character position of the first line. Special control characters denoted by seldomly used special symbols are provided in the system to signify the end of a line and the end of a page for the automatic skipping of the rest of the line or page.

V. CHARACTER STORAGE AND RETRIEVAL

1. Identification Code

A unique code is assigned for each character appearing in any one of the languages involved in the system for identification purpose. The numerical code in decimal digits as discussed under Character Representation is a simple and arbitrary method and can be readily applied to any language. For alphabetic languages, to associate the two decimal-digit codes with the alphabet requires only a couple of hours of actual coding work. For non-alphabetic languages, as in the worst example of 10,000 Chinese characters, the first author with no previous experience of the Chinese telegraphic code system but with sufficient background in the Chinese language, did the complete coding of the Chinese classics, the Four Books, in the Summer of 1964 with the aid of a code reference handbook. By late summer of 1964, the Chinese text could be read directly in telegraphic codes with less than 2% of reference to the code book. Since this method has been practiced in China for many years in telegraphic communications, the authors believe that there must be some very efficient training method for this telegraphic coding system.

The previously discussed Chicodes for Chinese character encoding on the Chicoder was experimented for operator training in 1965 at Itek Corporation. The result was that for an American secretary with no previous knowledge of the Chinese language, but with the aid of an instructional manual, four months of training will yield a typing speed of forty characters per minute including error corrections. However, the development of this kind of coding system will demand detailed analysis of stroke patterns for the particular language and the organization of characters in terms of these stroke patterns. Thus it is not readily available and too costly a technique to implement for other less complicated languages.

Both of the code assignment method may be used in the system to index the stored coordinate groups associated with each of them. When the writing request of a certain character reaches the associated coordinate group, the coordinates are copied into a buffer area and are being analyzed, calculated and transformed into a sequence of plotter subroutine calls for writing the character on the plotter paper.

2. Accompanying Information

The identification code may also be used to index information associated with the specific character for additional references and operations. If this system is to serve both as an automatic writing device and an automatic dictionary for two or more languages, then all the information in a selected dictionary may be included in the system, such as the pronounciation guide, parts of speech and other syntactic information, the meaning (translation) and other semantic information, the associated phrases and idioms, and examples of usage.

3. Data Compression

Since the largest coordinate used in the two suggested grids is the decimal number fifteen, only four bits are needed to record one coordinate. Therefore, the coordinates may be packed into a four-bit segment of a computer word. This may not be necessary for the alphabetic languages because their character sets are very small in size, usually not more than sixty-four characters each set in binary coded decimal. However, for the non-alphabetic languages such as the Chinese with a 10,000-character set, the need for data compression is rather apparent if all of their coordinate groups are going to be stored in the core memory for the most efficient processing. It is estimated that an average complexity Chinese character can be packed into four 48-bit computer words and thus a computer with 65K memory (e.g., CDC 3600) will be able to accommodate the overwhelming 10,000 characters in 40K of memory and allow the other 25K of memory for the executive system, the program, and the input/output buffering operations.

VI. SYSTEM PERFORMANCE

This system is aimed to provide a good universal writing device for all languages, alphabetic and non-alphabetic alike, because of its graphic nature in treating characters of various languages. This is of particular advantage to the non-alphabetic languages since no practical and efficient typing or writing device has been created for their uses.

The system uses the plotter as its output device for writing characters directly on the paper to produce a clear and permanent hard copy. The alternative CRT display has a unique advantage of on-line monitoring or editing but is otherwise a more complex process and hardware system to produce a final hard copy, and thus inevitably too expensive for practical and efficient applications. From numerous job runs of the test program on the CDC 3600 a plotter page of standard 8-1/2 x 11 inch with 320 Chinese characters written will cost about one dollar and twelve cents. The estimate for the test program to be run on the Univac 1108 is approximately eighteen cents per page. It would be very interesting to know the cost for on-line plotting with a PDP-8 and a plotter since they are among the least expensive computing equipments available.

The system is programmed in the Fortran language so that it can be utilized through small or medium size computers with the least effort of adaptation. Any plotter with a step size of 0.01 or less is very satisfactory for output character writing. The output from this system is certainly suitable to be used as an original for further duplicating, photographing, and photoengraving. Multiple-color writings may be accomplished through the change of plotter pens or inks of various colors with the aid of in-line plotter controls.

Finally, the system is oriented toward the user's convenience in operating. All the user's controls and selections are specified in natural language vocabularies and punched on cards as the input data to the computer. No programming work is involved on the part of the ultimate user to cause unnecessary complications or difficulties in utilizing this system. The user's learning process requires only a few times of actual practice to achieve efficient system utilization.

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SAMPLE CONTROL AND DATA CARD IMAGES

```
            STORE
 0001       I              ONE
  2 7   14 7   -1
 0002       DING           FOURTH
  311   1211   7777   711    7 1    5 2   -1
 0003       CHI            SEVEN
  2 7   12 7   7777   512    5 2    8 1   12 2   12 3   -1
 0004       JAQ            TEN FEET
  211   1311   7777   1014   9 7    7 4    1 1   7777    411    5 7    9 3   13 0
 0005       SAN            THREE
  412   1012   7777   3 8   11 8   7777    1 3   13 3   -1
 0006       SHANQ          UP
  714    7 2   7777   7 8   11 8   7777    2 1   13 1   -1
 0007       SHIAH          DOWN
  112   1312   7777   712    7 1   7777    7 6   11 6   -1
 0008       BUH            NOT
  212   1212   7777   712    2 3   7777    712    7 2   7777    710   12 5   -1
 0009       GAY            BEGGAR
  213   1113   7777   613    6 7   7777    610   1010   7777    311    3 7   11 7
  6 1    2 3   -1
 0010       CHOOU          CLOWN
  313   1113    8 2   7777   713    4 2   7777    3 9    7 5   7777    1 2   13 2
 0011       CHIEE          MOREOVER
  1 1   13 1   7777   4 1    413   1013   10 1   7777    4 9   10 9   7777    4 5
 -1
 0012       PI             GRAND
  313   1113   7777   713    2 2   7777    713    7 2    5 3   7777    711   11 5
  2 2   12 2   -1
 0013       SHYH           WORLD
  614    6 4   10 4   1014   7777   312    3 2   13 2   7777    1 8   14 8   -1
 0014       BIING          THIRD
  313   1113   7777   1 1    110   1310   13 1   11 2   7777    713    5 2   7777
  9 2   -1
 0015       CHERNG         DEPUTY
  413   1013   711    7 2    5 3   7777    310    7 8    2 4   7777   1110    7 8
 7777    2 2   13 2   -1
 0016       DIOU           LOSE
  312   1113   7777   2 9   12 9   7777    1 6   13 6   7777    712    7 6    3 1
  9 4   -1
 0017       BINQ           AND
  414   611    6 1   7777   1013   811    8 1   7777    311   1111   7777    3 9
  6 5   7777   11 9   11 5   8 5   7777    2 1   13 1   -1
 0018       MEAN           HIDDEN
  213   1113   7777   613    6 7   7777    311    3 7    9 7   7777    710   1110
  9 1    5 2   -1
 0019       GOEN           DOWNSTROKE
  713    7 1   -1
 0020       GEH            CLASSIFIER
  2 7    713   12 7   7777   713    7 1    5 2   -1
 0021       IA             SLAVE GIRL
  314    7 9   1113   7777   7 9    7 0    4 1   -1
 0022       JONG           MIDDLE
  210   1210   12 5   2 5    210   7777    714    7 0   -1
 0023       FENG           ABUNDANT
  3 9   1113   7777   3 7   11 7   7777    1 4   13 4   7777    714    7 0   -1
 0024       GUANN          TUFTS OF HAIR
  212    2 6    5 6   7777   514    5 4    2 0   7777    714    7 0   7777    7 6
 1112   -1
 0025       CHUANN         STRING
  412   1012   1010   410    412   7777    2 8   12 8   12 4    2 4    2 6   7777
  7 0   -1
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0026        AH        ACTINIUM
   1 8   414   612  7777   210   610  7777   2 6   6 6  7777   1 1   6 1  7777
   2 4   4 1   6 4  7777   614   914   911   810   9 9   9 6   7 6   714   7 1
  7777  1014  1414  1314  13 1  11 2  7777  1011  1211  12 4  10 4  1011  7777
   410   4 1    -1
0027        JUU       A POINT
   4 8  10 4    -1
0028        AI        EINSTEINIUM
   1 8   414   612  7777   210   610  7777   2 6   6 6  7777   1 1   6 1  7777
   2 4   4 1   6 4  7777   914  1112  7777   712  1412  7777   9 8   911  1311
  13 8   9 8  10 8   7 4  7777   9 6   9 1  11 2  7777  13 7   9 4  14 2  7777
   410   4 1    -1
0029        WAN       PILL
   211  1011  10 1  12 0  14 1  14 3  7777   514   5 5   0 0  7777   3 9   7 5
    -1
0030        DAN       CINNABAR
   3 0   4 5   413  1113  11 0   7 1  7777   1 5  13 5  7777   611   8 7    -1
0031        JUU       MASTER
   210  1210  7777   2 5  12 5  7777   1 1  13 1  7777   713   7 1    -1
0032        AY        ASTATINE
   013   613  7777   313   0 5  7777   1 7   5 7   5 1   1 1   1 7  7777   814
   8 9  7777  1114  11 9  7777   611  1311  7777   7 9  10 4  14 0  7777  12 9
  10 4   6 0    -1
0033        PIEE      LEFT DOWNSTROKE
   913   8 8   7 4   2 0    -1
0034        YIH       MOW
  1113  10 8   6 4   1 0  7777   313   5 8  10 1  13 0    -1
0035        NAE       THEREUPON
   213  1213   810  1310  13 6  11 0   6 1  7777   513   4 6   0 0    -1
0036        JEOU      LONG TIME
   514   2 6  7777   512   912   7 6   2 0  7777   6 5  11 0  14 0    -1
0037        JY        HIM/HER/IT
   514   711  7777   311  1111   7 7   0 5  11 2  14 3    -1
0038        JAH       SUDDENLY
   514   1 9  7777   412  1112  7777   512   5 0  7777   5 8  10 8  7777   5 4
  10 4    -1
0039        HU        (INTERROG.PART.)
  1013   411  7777   4 9   6 7  7777  10 9   8 7  7777   1 5  13 5  7777   712
   7 0   4 1    -1
0040        FAR       TIRED
   313  1014  7777   613   610  7777   210  1110   1 3   9 1  14 3    -1
0041        GUAI      CLEVER
   414  1014  7777   111  1311  7777   714   7 0   5 1  7777   510   5     2 5
  7777   2 8   5 8  7777   910   9 5  12 5  7777   9 8  12 8    -1
0042        CHERNG    MULTIPLY
   414  1014  7777   112  1312  7777   714   7 0   5 1  7777   511   5 7   2 7
  7777   2 9   5 9  7777   911   9 7  12 7  7777   9 9  12 9  7777   0 1   4 3
   7 7  10 3  14 1    -1
0043        AN        EUCALYPTUS
   111   611  7777   414   4 0   2 1  7777   0 3   6 9  7777  1014  1011  7777
   7 9   712  1312  13 9  7777   6 6  14 6  7777   8 9   8 4  14 0  7777  12 9
  12 4   6 0    -1
0044        YII       SECOND
   313  1113   3 7   2 3   3 1  13 1  13 3    -1
0045        MHIE      SQUINT
   1 8  1112   9 6  7777   414   4 2   6 1  13 1  13 3    -1
0046        JEOU      NINE
   210   910   8 6   9 2  11 1  13 2  13 4  7777   514   510   4 4   1 0    -1
0047        CHII      BEGG
   614   410  7777   512  1212  7777   610  1010   4 4   5 0  13 1  13 4    -1
0048        YEE       ALSO
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  110  1112  10 6  7777   714   7 7  7777   312   3 3  13 1  14 3   -1
0049       GAN        DRY
  013   613  7777   314   311   011   611   6 7   0 7   011   0 9   6 9  7777
  0 5   6 5  7777   0 3   6 3  7777   3 5   3 0  7777   814   711  7777   813
 1413  7777   811  1211   8 7   7 1  12 0  14 1  14 3   -1
0050       RUU        MILK
  714   111  7777   211   3 9  7777   412   4 9  7777   613   5 9  7777   2 8
  6 8   4 6   4 0   2 1  7777   0 4   8 4  7777   813   8 1  11 0  14 1  14 4
  -1
0051       GAN        DRY
  013   613  7777   314   311   011   611   6 7   0 7   011   0 9   6 9  7777
  0 4   6 4  7777   3 7   3 0  7777   814   711  7777   813  1413  7777   811
  211   8 7   7 1  12 0  14 1  14 3   -1
0052       LUANN      DISORDERED
  113   714  7777   213   311  7777   413   411  7777   613   511  7777   111
  711   4 9   310   5 6  7777   1 0   1 8   7 8   7 0  7777   4 8   2 5   6 5
  4 7  7777   2 1   6 4   2 4   6 1  7777   814   8 1  11 0  14 1  14 4   -1
0053       GAN        POOL
  113   613   1 9   0 4   4 1  12 1  14 4  7777   914   9 2   7 4  7777   510
  9 8   4 4  7777  1211   9 8  13 4   -1
0054       JYUE       MARK OFF
  714   7 0   3 2   -1
0055       LEQU       FINISH
  313  1113   710   7 0   4 2   -1
0056       YEU        TO GIVE
  314  1114   711  7777   512   810  7777   110  1310  11 8  7777   710   7 0
  4 2   -1
0057       SHYH       WORK/AFFAIR
  113  1313  7777   312   7 9  1112  7777   2 9  12 9  12 4   2 4  7777   3 6
 12 6  7777   714   7 0   4 1   -1
0058       BEEN       BENZENE
  113  1313  7777   414   510  7777  1014   910  7777   3 9  12 9  7777   711
  7 0  7777   0 3   7 9  14 3  7777   3 5  11 5   -1
0059       ELL        TWO
  311  1111  7777   1 4  13 4   -1
0060       YU         AT/IN
  313  1113  7777   713   7 0   3 1  7777   1 8  13 8   -1
0061       YUN        CLOUD
  413  1013  7777   1 9  13 9  7777   7 9   2 1  12 1   8 5   -1
0062       HUH        MUTUALLY
  313  1113  7777   713   2 5   7 5  7777   5 9  10 9   5 1  7777   0 1  14 1
  -1
0063       WUU        FIVE
  312  1112  7777   912   2 1  7777   3 8  12 8   9 1  7777   0 1  14 1   -1
0064       JIING      WELL
  311  1111  7777   1 6  13 6  7777   514   5 5   4 0  7777   914   9 0   -1
0065       GENQ       ACROSS/THROUGH
  313  1113  7777   713   3 7   7 3  7777   711  11 9   7 1  7777   5 9   9 6
 7777   0 1  14 1   -1
0066       KUANQ      SITUATION
  213   611  7777   1 1   6 7  7777   714  1314  13 8   7 8   714  7777  10 8
  8 3   5 1  7777  10 8  11 1  14 1  14 3   -1
0067       SHIE       SOME
  212   2 6  7777   414   4 7  7777   410   710  7777   0 5   6 7  7777   614
  8 6  14 6  14 8  7777   4 4  10 4  7777   1 1  13 1  7777   610  1310   -1
0068       YEA        ASIA
  313  1113  7777   613   6 8   2 8   2 5   6 5   6 1  7777   813   3 8  12 8
 12 5   8 5   8 1  7777   0 1  14 1   -1
0069       JYI        URGENT
  313  1113   710   7 1   5 2  7777   2 9   6 9   6 5   2 5   2 9  7777   8 4
 12 9   8 9  12 4  7777   1 1  13 1   -1
```
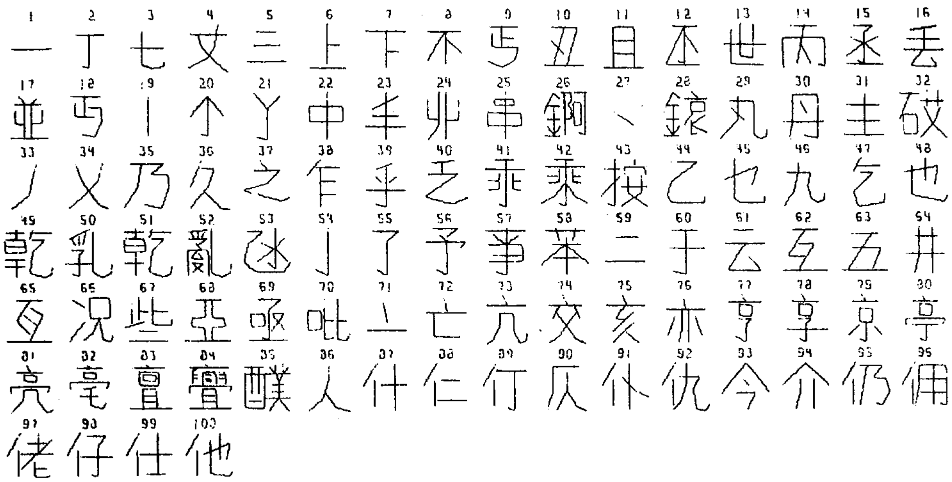

```
        BI             PYRENE
10     510     5 4       1 4     110    7777    613     6 1     9 2   7777    6 7     9 7   7777
13    10 1    13 1     14 3    7777    10 7    13 7    -1
        TOUR           ABOVE
12     7 6    7777      1 4    13 4    -1
        WANG           PERISH
13     7 9    7777      1 9    13 9    7777     3 9     3 2    11 2    -1
        KANQ           OVERBEARING
14     711    7777      111    1311    7777     1 0     3 1     5 5     5 9     9 9     9 3    11 0
 1    13 3    -1
        JIAU           JOIN
14     711    7777      211    1211    7777     511     3 7    7777     4 9    10 1    13 0    7777
11    11 7    7777     10 9     5 2     2 0    -1
        HAY            TWELFTH
14     711    7777      111    1311    7777     711     4 7     7 7    7777     9 9     3 3    7777
 6     3 0    7777      7 3    11 0    -1
        YIH            ALSO
14     710    7777      110    1310    7777     610     6 4     5 0    7777     810     8 0    7777
 8     2 2    7777     10 8    12 2    -1
        HENG           PROSPEROUS
14     712    7777      212    1212    7777     511     5 8     9 8     911     511    7777     5 7
 7     7 5     7 0      4 2    -1
        SHEANG         ENJOY
14     712    7777      312    1112    7777     511     5 8     9 8     911     511    7777     5 7
 7     7 5     7 0      5 1    7777     1 4    14 4    -1
        JING           CAPITAL
14     712    7777      312    1112    7777     510     5 6     9 6     910     510    7777     7 6
 0     5 1    7777      5 5     2 2    7777     9 5    12 2    -1
        TYNG           PAVILION
14     712    7777      312    1112    7777     511     5 8     9 8     911     511    7777     1 5
 7    13 7    12 5     7777     3 5    11 5    7777     7 5     7 0     5 1    -1
        LIANG          BRIGHT
14     712    7777      312    1112    7777     511     5 9     9 9     911     511    7777     1 6
 8    13 8    12 6     7777     1 0     5 4     5 7     9 7     9 3    12 0    14 1    -1
        BOH            (DISTRICT NAME)
14     713    7777      313    1113    7777     512     510     910     912     512    7777     1 7
 9    13 9    12 7     7777     5 7     9 8    7777     7 7     7 2    11 1    12 3    7777     4 5
 5    -1
        DAAM           SINCERE
14     713    7777      213    1213    7777     412     4 8    10 8    1012     412    7777     511
 9     9 9     911      511    7777     5 1     5 7     9 7     9 1    7777     5 5     9 5    7777
 3     9 3    7777      1 1    14 1    -1
        WOEI           RESOLUTE
14     713    7777      113    1313    7777     413     212     2 8    7777     211     411    7777
10     410    7777      5 8     512     912     9 8    7777     611     811    7777     610     6 9
 9     810     610     7777    1012    1212    12 8    7777    1011    1211    7777    1010    1210
77     1 6     1 8     14 8    13 6    7777     5 1     5 7     9 7     9 1    7777     5 5     9 5
77     5 3     9 3     7777     1 1    14 1    -1
        BWU            MOLD ON LIQUIDS
13     613    7777      011     0 1     6 1     611     011    7777     213     2 5    7777
 5    7777     1 3      5 3    7777     713     911     914    7777    1114    1111    1313    7777
11    1411    7777      911    10 8    1111    7777     8 8    12 8    7777     8 6    12 6    7777
 4    14 4    7777     10 8    10 4     7 0    7777    10 4    13 0    -1
        REN            PERSON
13     7 9     5 3      1 0    7777     6 6     9 1    14 0    -1
        SHER           WHAT
14     0 7    7777      3 9     3 1    7777     5 8    13 8    7777     914     9 0    -1
        REN            HUMANE
14     0 7    7777      3 9     3 1    7777     5 9    11 9    7777     4 3    13 3    -1
        DINE           ALONE
14     0 7    7777      3 9     3 1    7777     412    1312    7777     912     9 0     7 1    -1
```

```
0090       TEEH      OBLIQUE TONE
   1 0   3 6   313  1113  7777   711    7 6    4 0   7777    7 6   10 1   13 0   -1
0091       PU        FALL PROSTRATE
  414    0 7  7777   3 9    3 1  7777   814    8 0   7777    610   10 6   14 4   -1
0092       CHOUR     ENMITY
  414    0 7  7777   3 9    3 1  7777   714    7 8    5 2    3 0  7777   510   1110
   9 6  10 0  13 0  14 2   -1
0093       JIN       NOW
   0 5   714  14 5  7777   6 9    8 7  7777    4 5   10 5    7 0    -1
0094       JIEH      LIE BETWEEN
   0 7   714  14 7  7777   5 9    5 5    4 0   7777    9 9    9 0    -1
0095       RENG      STILL
   14    0 7  7777   3 9    3 1  7777   513   1213    9 9   13 9   14 5   12 1   10 2
   77    713   5 1   -1
0096       TONG      SERVANT
  414    0 7  7777   3 9    3 1  7777    4 1    5 7    513   1313   13 1   11 2   7777
   5 9  13 9  7777   5 5   13 5  7777   913    9 1    -1
0097       LAO       MAN
  414    0 7  7777   3 9    3 1  7777   611   1211   7777    4 8   14 8   7777    914
    8   7777  1312   4 3  7777   8 6    8 1   11 1   13 2   7777    8 4   12 4   -1
0098       TZYY      MINUTELY
  414    0 7  7777   3 9    3 1  7777   613   1213    910    9 1    7 2   7777    4 7
  14 7   -1
0099       SHYH      AN OFFICIAL
  414    0 7  7777   3 9    3 1  7777    4 8   14 8   7777    914    9 2   7777    6 2
  12 2   -1
0100       TA        HE/SHE
  414    0 7  7777   3 9    3 1  7777    5 8   1311   12 6   7777   1014   10 6   7777
  712    7 2  13 1  14 3   -1
           DISPLAY
CHINESE
HORIZONL
  0.025
           TELE      TELE
0001 0002 0003 0004 0005 0006 0007 0008 0009 0010 0011 0012 0013 0014 0015 0016
0017 0018 0019 0020 0021 0022 0023 0024 0025 0026 0027 0028 0029 0030 0031 0032
0033 0034 0035 0036 0037 0038 0039 0040 0041 0042 0043 0044 0045 0046 0047 0048
0049 0050 0051 0052 0053 0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064
0065 0066 0067 0068 0069 0070 0071 0072 0073 0074 0075 0076 0077 0078 0079 0080
0081 0082 0083 0084 0085 0086 0087 0088 0089 0090 0091 0092 0093 0094 0095 0096
0097 0098 0099 0100 -100
CHINESE ENGLISH
HORIZONL
  025
           TELE
0001 0002 0003 0004 0005 0006 0007 0008 0009 0010 0011 0012 0013 0014 0015 0016
0017 0018 0019 0020 0021 0022 0023 0024 0025 0026 0027 0028 0029 0030 0031 0032
0033 0034 0035 0036 0037 0038 0039 0040 0041 0042 0043 0044 0045 0046 0047 0048
0049 0050 0051 0052 0053 0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064
0065 0066 0067 0068 0069 0070 0071 0072 0073 0074 0075 0076 0077 0078 0079 0080
0081 0082 0083 0084 0085 0086 0087 0088 0089 0090 0091 0092 0093 0094 0095 0096
0097 0098 0099 0100 -100
CHINESE
HORIZONL
  0.025
           TELE
0001 0002 0003 0004 0005 0006 0007 0008 0009 0010 0011 0012 0013 0014 0015 0016
0001 0002 0003 0004 0005 0006 0007 0008 0009 0010 0011 0012 0013 0014 0015 0016
0001 0002 0003 0004 0005 0006 0007 0008 0009 0010 0011 0012 0013 0014 0015 0016
0001 0002 0003 0004 0005 0006 0007 0008 0009 0010 0011 0012 0013 0014 0015 0016
```

```
0018 0019 0020 0021 0022 0023 0024 0025 0026 0027 0028 0029 0030 0031 0032
0018 0019 0020 0021 0022 0023 0024 0025 0026 0027 0028 0029 0030 0031 0032
0018 0019 0020 0021 0022 0023 0024 0025 0026 0027 0028 0029 0030 0031 0032
0018 0019 0020 0021 0022 0023 0024 0025 0026 0027 0028 0029 0030 0031 0032

0034 0035 0036 0037 0038 0039 0040 0041 0042 0043 0044 0045 0046 0047 0048
0034 0035 0036 0037 0038 0039 0040 0041 0042 0043 0044 0045 0046 0047 0048
0034 0035 0036 0037 0038 0039 0040 0041 0042 0043 0044 0045 0046 0047 0048
0034 0035 0036 0037 0038 0039 0040 0041 0042 0043 0044 0045 0046 0047 0048

0050 0051 0052 0053 0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064
0050 0051 0052 0053 0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064
0050 0051 0052 0053 0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064
0050 0051 0052 0053 0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064
0066 0067 0068 0069 0070 0071 0072 0073 0074 0075 0076 0077 0078 0079 0080
0066 0067 0068 0069 0070 0071 0072 0073 0074 0075 0076 0077 0078 0079 0080
0066 0067 0068 0069 0070 0071 0072 0073 0074 0075 0076 0077 0078 0079 0080
0066 0067 0068 0069 0070 0071 0072 0073 0074 0075 0076 0077 0078 0079 0080

0082 0083 0084 0085 0086 0087 0088 0089 0090 0091 0092 0093 0094 0095 0096
0082 0083 0084 0085 0086 0087 0088 0089 0090 0091 0092 0093 0094 0095 0096
0082 0083 0084 0085 0086 0087 0088 0089 0090 0091 0092 0093 0094 0095 0096
0082 0083 0084 0085 0086 0087 0088 0089 0090 0091 0092 0093 0094 0095 0096

0098 0099 0100
0098 0099 0100
0098 0099 0100
0098 0099 0100 -100
ESE ENGLISH
ZONL
025
     TELE
0034 0035 0036 0037 0038 0039 0040 0041 0042 0043 0044 0045 0046 0047 0048
          0054 0055 0056 0057 0058 0059 0060 0061 0062 0063

               0055 0056 0057 0058 0059 0060 0061 0062
0002 0003 0016 0004 0017 0005 0006 0007 0001 0001 0001 0001 0018 0002 0016
0002 0003 0004 0005 0006 0007 0008                0012 0013 0014      0016
0076 0077 0078 0079 0080 0081 0082 0083 0084 0085 0086 0087 0088 0089 0090
     0003      0005      0007      0009      0011      0013      0015
0068 0069 0070 0071 0072 0073 0074  -10
ESE
ZONL
025
     TELE      TELE
0018 0019 0020 0021 0022 0023 0024 0025 0026 0027 0028 0029 0030 0031 0032
0050
               0055 0056 0057 0058 0059 0060 0061 0062 0063


     0053 0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064
0092 0093 0094 0095 0096 0097 0098 0099 0100
0002 0003 0016 0004 0017 0005 0006 0007                0001 0018 0002 0016
          0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064
0052 0053 0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064 0065 0066
     0053 0054 0055 0056 0057 0058 0059 0060 0061 0062 0063 0064 0065 0066
0098 0099 0100

0002 0003 0004 0005 0006 0007 0008 0009 0010 0011 0012 0013 0014 0015 0016
0034 0035 0036 0037 0038 0039 0040 0041 0042 0043 0044 0045 0046 0047 0048
0076 0077 0078 0079 0080 0081 0082 0083 0084 0085 0086 0087 0088 0089 0090
```

SAMPLE PLOTTER OUTPUT



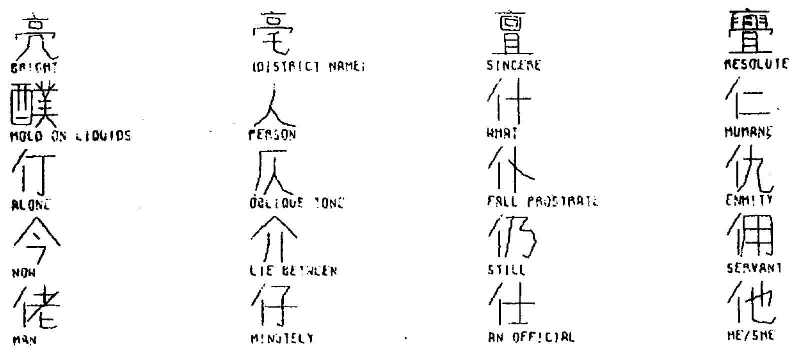
OUTPUT PAGE 1: The first one-hundred Chinese characters of the Chinese telegraphic code -- horizontal writing, Chinese characters at step size 0.025 inch, code number at step size 0.01 inch.

一 ONE
三 THREE
丐 BEGGAR
世 WORLD
並 AND
丫 SLAVE GIRL
串 STRING
丸 PILL
丿 LEFT DOWNSTROKE
之 HIM/HER/IT
乖 CLEVER
乜 SQUINT
乾 DRY
氹 POOL
事 WORK/AFFAIR
云 CLOUD
亙 ACROSS/THROUGH
亟 URGENT
亢 OVERBEARING
亨 PROSPEROUS

丁 FOURTH
上 UP
丑 CLOWN
丙 THIRD
丏 HIDDEN
中 MIDDLE
錒 ACTINIUM
丹 CINNABAR
乂 MOW
乍 SUDDENLY
乘 MULTIPLY
九 NINE
乳 MILK
亅 MARK OFF
苯 BENZENE
互 MUTUALLY
況 SITUATION
吡 PYRENE
交 JOIN
享 ENJOY

七 SEVEN
下 DOWN
且 MOREOVER
丞 DEPUTY
丨 DOWNSTROKE
丰 ABUNDANT
丶 A POINT
主 MASTER
乃 THEREUPON
乎 (INTERROG. PART.)
按 EUCALYPTUS
乞 BEG
乾 DRY
了 FINISH
二 TWO
五 FIVE
些 SOME
丄 ABOVE
亥 TWELFTH
京 CAPITAL

丈 TEN FEET
不 NOT
丕 GRAND
丟 LOSE
个 CLASSIFIER
丱 TUFTS OF HAIR
鎄 EINSTEINIUM
砹 ASTATINE
久 LONG TIME
乏 TIRED
乙 SECOND
也 ALSO
亂 DISORDERED
予 TO GIVE
于 AT/IN
井 WELL
亞 ASIA
亡 PERISH
亦 ALSO
亭 PAVILION



OUTPUT PAGES 2 & 3: The same one-hundred Chinese characters with their English Equivalents -- horizontal writing, Chinese characters at step size 0.025 inch, English letters at step size 0.01 inch.

一丁七丈三上下不丐丑且丕世丙丞丟
一丁七丈三上下不丐丑且丕世丙丞丟
一丁七丈三上下不丐丑且丕世丙丞丟
一丁七丈三上下不丐丑且丕世丙丞丟

並丏丨个丫中丰丱串鋼丶鑲丸丹主破
並丏丨个丫中丰丱串鋼丶鑲丸丹主破
並丏丨个丫中丰丱串鋼丶鑲丸丹主破
並丏丨个丫中丰丱串鋼丶鑲丸丹主破

丿乂乃久之乍乎乏乖乘按乙乜九乞也
丿乂乃久之乍乎乏乖乘按乙乜九乞也
丿乂乃久之乍乎乏乖乘按乙乜九乞也
丿乂乃久之乍乎乏乖乘按乙乜九乞也

乾乳乾亂氹亅了予事苯二于云互五井
乾乳乾亂氹亅了予事苯二于云互五井
乾乳乾亂氹亅了予事苯二于云互五井
乾乳乾亂氹亅了予事苯二于云互五井
亙况些亞亟吡亠亡亢交亥亦亨享京亭

亙况些亞亟吡亠亡亢交亥亦亨享京亭
亙况些亞亟吡亠亡亢交亥亦亨享京亭
亙况些亞亟吡亠亡亢交亥亦亨享京亭

亮亳亶亹醭人什仁仃仄仆仇今介仍佣
亮亳亶亹醭人什仁仃仄仆仇今介仍佣
亮亳亶亹醭人什仁仃仄仆仇今介仍佣
亮亳亶亹醭人什仁仃仄仆仇今介仍佣

佬仔仕他
佬仔仕他
佬仔仕他
佬仔仕他

OUTPUT PAGES 4 & 5: Chinese characters, a horizontal writing mode and at step size 0.025 inch, arranged at 320 Characters per page for continuous text writing.

丿
LEFT DOWNSTROKE
之
HIM/HER/IT
乖
CLEVER
乜
SQUINT

乂
MOW
乍
SUDDENLY
乘
MULTIPLY
九
NINE

乃
THEREUPON
乎
(INTERROG. PART.)
桉
EUCALYPTUS
乞
BEG

久
LONG TIME
乏
TIRED
乙
SECOND
也
ALSO
亅
MARK OFF

了
FINISH
二
TWO
五
FIVE

予
TO GIVE
于
AT/IN

事
WORK/AFFAIR
云
CLOUD

苯
BENZENE
互
MUTUALLY

了
FINISH
二
TWO

予
TO GIVE
于
AT/IN

事
WORK/AFFAIR
云
CLOUD

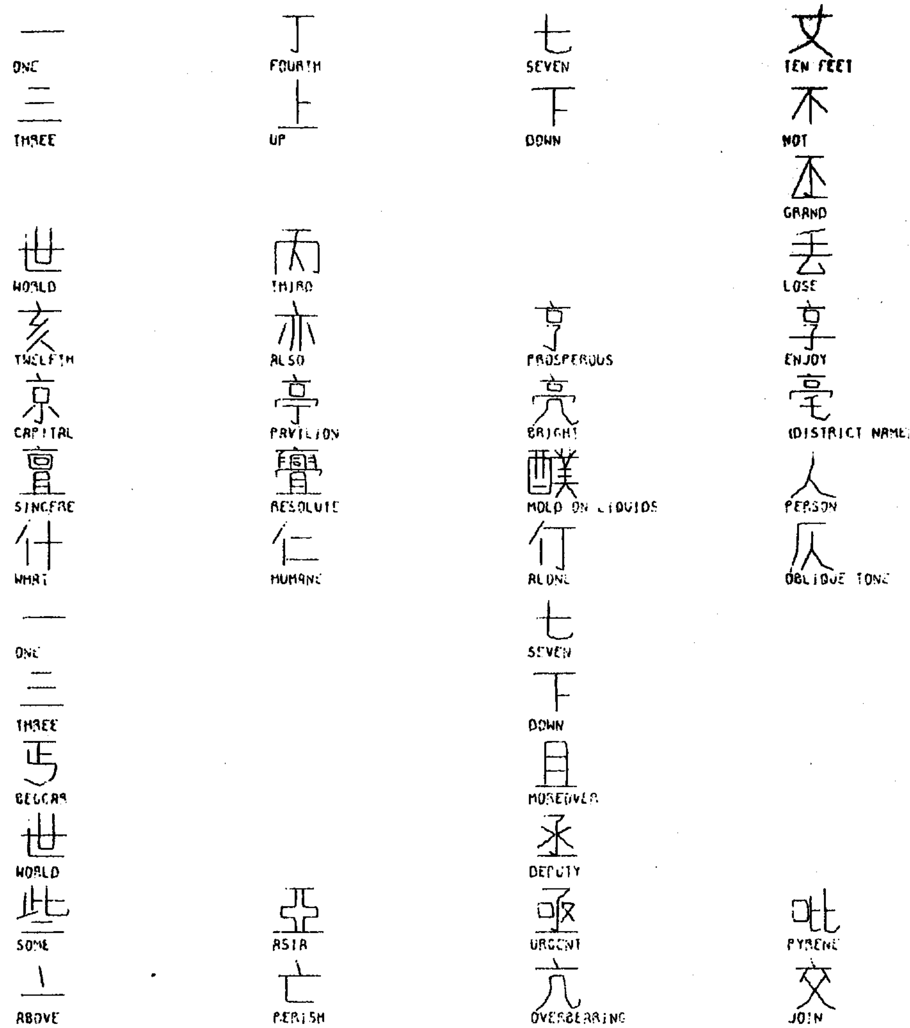
苯
BENZENE
互
MUTUALLY

一
ONE
丈
TEN FEET
下
DOWN
一
ONE

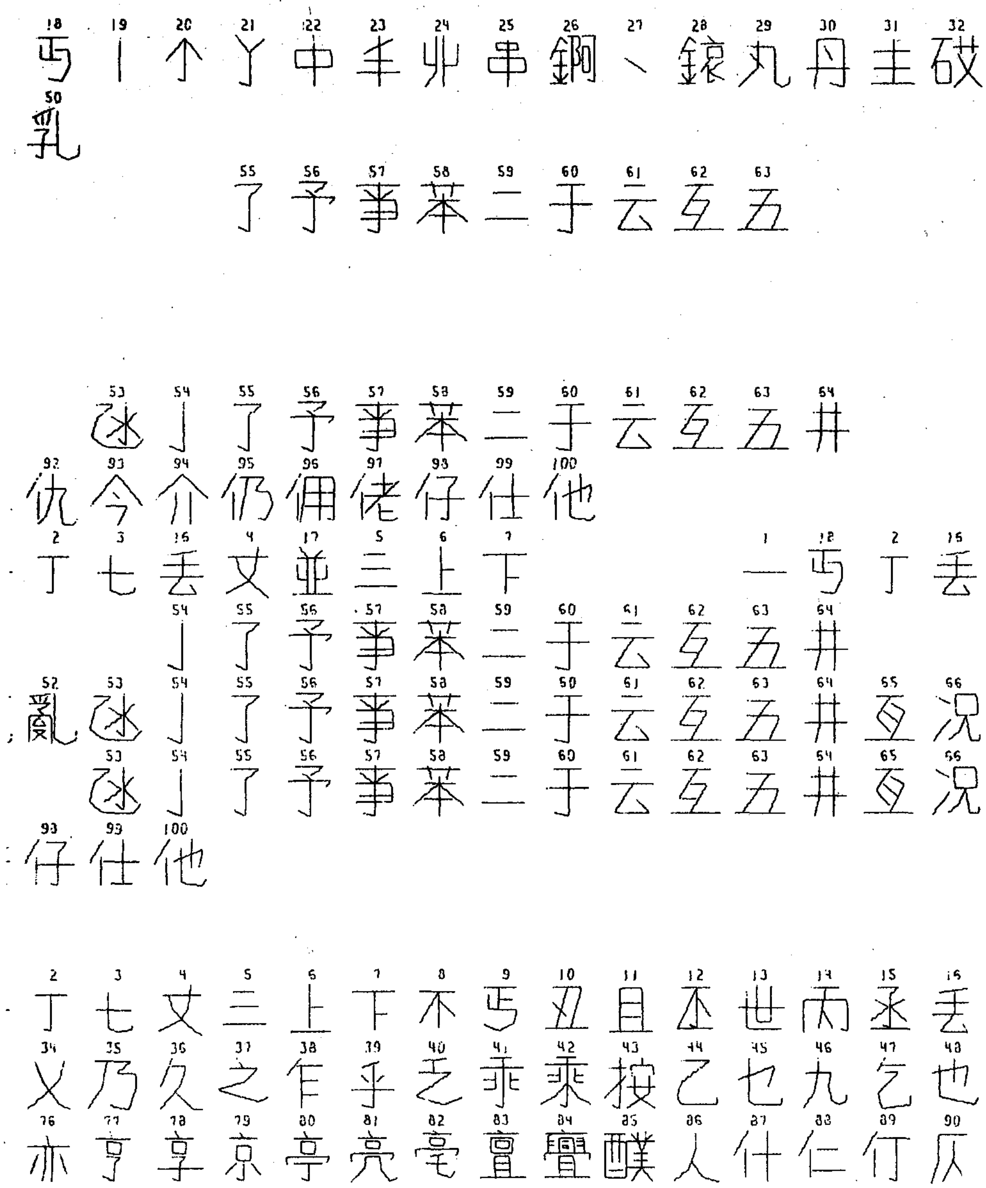
丁
FOURTH
並
AND
一
ONE
丏
HIDDEN

七
SEVEN
三
THREE
一
ONE
丁
FOURTH

丢
LOSE
上
UP
一
ONE
丢
LOSE



OUTPUT PAGES 6 & 7: Chinese characters with English equivalents arranged at 80 characters per page with blank spaces and lines randomly filled inside the text.



OUTPUT PAGE 8: Chinese characters with identifying telegraphic codes arranged at 320 characters per page with space and line controls.